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HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

Under the joint supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE
AND THE UNIVERSITY OF HAWAII

U.S. DEPARTMENT OF AGRICULTURE
JAN 29 1935

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

1933

Issued April 1934

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the joint supervision of the Office of Experiment Stations, U.S. Department of Agriculture, and the University of Hawaii]

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[1] Appointment effective Dec. 1, 1932.
[2] Designated Jan. 2, 1933.
[3] Designated Sept. 1, 1932.

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INTRODUCTION

Recent low prices for sugar and pineapples, the leading products of Hawaii, have led growers of those products to give attention to the utilization of their marginal and submarginal lands for the production of other crops. The station has been called on repeatedly for advice and assistance about the establishment of supplemental crops on the sugar and pineapple plantations—not only on marginal and submarginal lands but also on lands that have been or may be thrown out of production through quota-production adjustments.

The producers of both sugar and pineapples are able to finance their own experiment stations, and the station is thus left free to investigate questions relating to the development of minor crops and to encourage the production of those which may have export value or are not produced in sufficient quantity to supply local needs.

The station is therefore, in response to numerous calls for information and advice, giving considerable attention to the possibility of increasing the production of some of the more important minor crops. An example of station work in this direction is an effort to determine the possibilities of out-of-season production of potatoes. In various other ways the station is endeavoring to develop a more diversified and self-sustaining agriculture in the islands.

An outstanding development of the work of the station during the year was the adaptation of the pot-test method based on the Mitscherlich principle[1] to the determination of the fertilizer requirements of the diversified crops and different soil types of the Territory. The method successfully used by the experiment station of the Hawaiian Sugar Planters' Association to determine the fertilizer requirements of sugarcane was applied to other crops, such as rice, potatoes, cabbage, and coffee, as shown later in this report. In the Mitscherlich pot method, so-called "indicator" crops are grown in specially designed pots of the soil to be tested with varying amounts and combinations of fertilizer nutrients, and the increment in yield is taken as a measure of fertilizer needs. Sudan grass has been found to give excellent results as an indicator crop for sugarcane, but whether it is an equally reliable indicator of the plant-food requirements of such widely different plants as cabbage, potatoes, coffee, and rice is being studied by the station.

To afford proper protection for the pot tests and to control the conditions surrounding them, four open, lath, or screen-sided greenhouses were constructed, each designed for a particular crop and so arranged that by simple manipulation the amount of sunlight, temperature, and humidity can be controlled and a variety of crops grown the year around under the conditions best suited to them. For example, rice and Sudan grass can be grown in full sunlight, coffee can be grown in the partial shade it requires, and leafy vegetables that wilt badly without protection can be kept succulent and vigorous. A so-called "humidifier" was constructed which throws a fine spray into the enclosure and very effectively reduces the temperature and rate of transpiration and prevents wilting during the hottest weather. The greenhouses are long and narrow, to provide more uniform light conditions. The sides are left open except during very windy weather, when lath frames are put up to protect the plants. The roofs consist of window sashes hinged at the ridge pole and fastened together in sections so that they can be raised and lowered at will. This type of construction has proved adequate for greenhouse work throughout the year under the local conditions.

The pot-test equipment and technic developed by the station are being used to correlate the results of such tests with those of field experiments with various crops and soils, as later pages show. The modified Mitscherlich method has also been under observation by the division of vocational education of the Territory of Hawaii and is being adopted for use by schools in various parts of the islands.

Satisfactory progress was made in all station projects despite curtailed Federal and Territorial financial resources.

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[1] MITSCHERLICH, E. A. DIE BESTIMMUNG DES DÜNGERBEDÜRFNISSES DES BODENS. 119 p. Berlin. 1930.

Vegetative propagation of tropical horticultural crops continued to receive special attention. Cooperative experiments with such crops were carried on with more than 50 private growers in suitable localities throughout the islands under different conditions of soil and climate.

The new plantings in the recently established economic tropical arboretum have made an excellent start.

New lines of work at the station included nutritional studies of coffee, Macadamia nut, cabbage, potatoes, rice, and Sudan grass. Old lines of work completed or suspended included cultural and spacing investigations with green-manure crops and the making of insecticides from nicotine derivatives.

The poultry industry has been greatly benefited by the development by the station of successful methods of chick and turkey poult vaccination against fowl pox ("sorehead").

An electrical refrigeration plant was installed in the dairy, several small unit poultry houses were constructed, and a much-needed automobile was purchased for use in carrying members of the station staff to outlying station activities.

Preliminary arrangements were made for the purchase by the Territory of about 1.5 acres of land adjoining the Kona substation. This area is to be used for testing block plantings of recently introduced species of coffee.

The total income of the station for the year was $94,500, including $15,000 from the Hatch fund, $9,000 from the Adams fund, $30,500 from Territorial sources, and $40,000 from Federal appropriations through the United States Department of Agriculture. The corresponding figures for the preceding fiscal year were, Hatch fund $15,000, Adams fund $7,000, funds from Territorial sources $32,252, and Federal appropriations through the Department of Agriculture $43,520, making a total of $97,772.

PROJECTS

Research projects active during the year and their leaders were: Studies of the physical and chemical composition of tropical soils (J. C. Ripperton); correlation between the magnitude of the sesquioxide ratio in an extracted soil colloid and soil-moisture availability (H. A. Wadsworth); breeding and selection of pigeonpeas, factors affecting seed production of green-manure crops, and breeding and yield studies of forage crops (C. P. Wilsie); relation of chemical composition of range grasses to pasture management (D. W. Edwards); varietal, cultural, and propagation studies of citrus, culture and breeding of Hawaiian raspberries (Akala berry, *Rubus* sp.), and varietal, cultural, and propagation studies of Macadamia nuts (W. T. Pope); factors affecting chemical composition of Macadamia nuts (J. C. Ripperton); varietal, cultural, and propagation studies of coffee (W. T. Pope); rejuvenation of old coffee plantings, and nutrition and fertilizer studies of the coffee plant (J. C. Ripperton); variety tests and breeding studies of vegetable crops (C. P. Wilsie); can molasses for dairy cows, sprouted oats for correcting breeding problems of dairy cows and brood sows, and sugar and molasses feeding of swine (L. A. Henke); control of sorehead of baby chicks and poults, sex determination of day-old purebred chicks, battery brooding of chicks, feeding cane molasses to baby chicks and laying hens, and all-mash method of feeding laying hens and turkeys (C. M. Bice); vitamins in Hawaiian foods and feeds, chemical and biological studies of protein in pigeonpeas, and chemical and biological studies of the opihi (C. D. Miller); nicotine content of Hawaiian-grown tobaccos, preparation of a nicotine stomach-poison insecticide, study of the sterol content and vitamin value of avocado oil, and iodine content of Hawaiian foods (L. N. Bilger); and variation in the electrolyte content and its effect on the strength of starch (J. C. Ripperton).

PUBLICATIONS

The following is a list of publications of the station during the year covered by this report:

Report of the Hawaii Agricultural Experiment Station, 1932; Bulletin 65, Range Grasses of Hawaii, by J. C. Ripperton, R. A. Goff, D. W. Edwards, and W. C. Davis; Bulletin 66, Survey of the Physical Features that Affect the Agriculture of the Kona District of Hawaii, by H. A. Powers, J. C. Ripperton, and Y. B. Goto; Bulletin 67, Cane Molasses in Poultry Rations, by C. M. Bice; Circular 5, Poultry Diseases Common in Hawaii, by C. M. Bice; and circular 6, Grafting Tropical Fruit Trees in Hawaii, by W. T. Pope and W. B. Storey. Articles contributed by the station included the following: Adsorption of Vitamin B (B_1) by Plant Tissue—I, Adsorption of Vitamin B (B_1) by *Brassica chinensis* when Pickled with Salt and Rice Bran, by C. D. Miller and M. G. Abel (Jour. Biol. Chem. 100: 731–735. 1933); Studies of the Nutritive Value of Opihi (*Helcioniscus exerata* and *H. argentatus*)—II, Hemoglobin Regeneration in Anemic Rats Fed Opihi, by C. D. Miller (Proc. Hawaiian Acad. Sci. 8th Ann. Meeting 1933. Bernice P. Bishop Mus. Spec. Pub. 21: 11–12. 1933); Further Observations Upon the Relation Between Cane Elongation and Soil Moisture, by H. A. Wadsworth (Hawaii. Planters' Rec. 36: 423–433. 1932): A Summary of Recent Irrigation Studies and Some Suggestions as to Future Investigations. by H. A. Wadsworth (Hawaii. Planters' Rec. 36: 237–239. 1932); Plant Wilt and Its Relation to the Ratio of Water Supply and Water Demand, by H. A. Wadsworth (Hawaii. Planters' Rec. 36: 273–278. 1932); The Optical Lever as a Tool in Physiological Studies, by H. A. Wadsworth (Plant Physiol. 7: 727–731. 1932); Some Factors Affecting the Electrolytes of the Starch Granules, by D. W. Edwards and J. C. Ripperton (Jour. Agr. Res. 47: 179–191. 1933); Family Food Budgets—Adequate Diets at Minimum Cost for Different Racial Groups in Hawaii, by C. D. Miller and the household staff of the University of Hawaii (Univ. Hawaii, Unnumbered Circ. 1933); The Iodine Content of Hawaiian Food Products, by E. M. Bilger, W. Hammond, and R. Loveland (Proc. Hawaiian Acad. Sci. 8th Ann. Meeting 1933. Bernice P. Bishop Mus. Spec. Pub. 21: 22–23. 1933); Some Chemical Investigations of the Avocado, by L. N. Bilger, W. Y. Young, and M. Westgate (Proc. Hawaiian Acad. Sci. 8th Ann. Meeting 1933. Bernice P. Bishop Mus. Spec. Pub. 21: 23. 1933); and A Survey of Dairying in Hawaii, by L. A. Henke (Univ. Hawaii Ext. Bul. 19. 1933).

SOILS

In continuation of work on the relation of colloid material and organic matter to soil moisture conditions and the wilting point of plants grown on the soil, detailed studies were made with 18 soils collected on the islands of Hawaii and Maui, which have been formed under widely varying conditions of rainfall and temperature. The results indicate that the ratios of soil moisture to permanent wilting point were surprisingly consistent for the entire series of soils. Numerical values for these ratios range from 1.37 to 1.22, but the probable errors involved indicated that the differences were not statistically significant. The silica-sequioxide ratios of the extracted soil colloids ranged from 0.41 to 1.86, the lower values being associated with soils originating on the windward or rainy side of the islands.

Determinations of organic matter by the wet combustion method indicated that the soils with low silica-sesquioxide ratios carried large percentages of organic matter, whereas soils with high values for the silica-sesquioxide ratio, as for example, those from the leeward sides of the islands, were extremely low in this material.

Three soils were prepared to test the effect of organic matter on the ratio of moisture equivalent to permanent wilting percentage. Soil no. 1 was a composite of several highly productive Maui soils, the silica-sesquioxide ratio of which was 1.44. Soil no. 2 was screened organic matter with some slight admixture of mineral soil. Soil no. 3 was a mixture of soils nos. 1 and 2 in equal proportions on the basis of oven-dry weights. The results of the test are shown in table 1.

TABLE 1.—*Ratio of moisture equivalent to wilting percentage in three soil samples*

Soil number	Moisture equivalent	Wilting percentage	Ratio
1	26.82±0.04	19.11±0.028	1.403±0.002
2	51.14± .17	37.01± .235	1.384± .011
3	38.12± .25	26.62± .045	1.431± .007

Further study of the effect of organic matter on the ratio of moisture equivalent to wilting percentage is now under way.

FIELD CROPS AND FORAGE PLANTS

RICE

A series of cooperative plat experiments was begun with the agricultural extension division of the University of Hawaii and with the rice growers of Kauai to determine the fertilizer needs of rice in the Hanalei district. The experiments are to be carried through several crops to determine the plant-food reserve in the soil. Pot tests to determine fertilizer requirements are being made by the Mitscherlich method, on soil taken from the experimental field, using rice as the indicator crop.

PIGEONPEAS

The isolation of pure strains of pigeonpeas (*Cajanus indicus*) and the selection of more desirable types for forage and for green-manure purposes was continued. Fifty of the most promising strains were self-pollinated by enclosing groups of the unopened buds in muslin bags. A fairly good set of seed was obtained in most instances, particularly when the foliage was removed from the branch before the bag was put on. A large proportion of the flowers open rather early in the morning, and the best time to cover the buds to assure selfing was found to be between 7 and 9 a.m.

A number of selections of the New Era strain D variety were selfed to determine whether it was becoming mixed through natural crossing or otherwise. The progeny of these selections is to be studied carefully to maintain the desirable characteristics of this standard type. Several single-plant selections were made from the variety Prensado, which offers possibilities of giving very prolific strains of better flavor for table use. These are being increased for further trial.

Two experiments to determine the amount of natural crossing that takes place between varieties planted in adjacent rows were started.

Samples of pigeonpea seed for trial were sent to New Zealand, South Africa, India, Seychelle Islands, and Trinidad, and to Wisconsin, California, Texas, and Tennessee.

SOYBEANS

Of 30 varieties of soybeans under test for 2 years, Biloxi, Mammoth Yellow, F.P.I. 80495, Laredo, Illini, F.P.I. 82548, Yellow Biloxi, and Edward have given the highest yields of seed at Honolulu. In forage yields Biloxi surpasses all the other varieties tested. Soybeans mature in less time in Hawaii than they do on the mainland. Biloxi, Laredo, and Edward, which mature in 140 to 170 days in Missouri, mature in 110 to 130 days at Honolulu. The difference in length of day is probably the most important factor causing a shorter period of growth in Hawaii.

Considerable local interest is being shown in the use of green soybeans as a vegetable. Preliminary tests made to learn their value in the dietary have shown the following strains and varieties to possess good flavor and to be suitable if the yields are satisfactory: F.P.I. 80483, which has a large, flat, yellow seed with a black saddle; F.P.I. 81780, which has a large straw-yellow seed; Mammoth Yellow; S.P.I. 40114, which has a medium-sized yellow seed; Yellow-Biloxi; and a large green-seeded local variety (Accession no. 2692). In general the varieties most suitable for use as green vegetables are not the highest-yielding kinds, and efforts are being made to select superior strains from some of the varieties that have the desired flavor.

For studies of composition and vitamin potency of green soybeans, see page 24.

GREEN-MANURE AND COVER CROPS

Further tests of legumes showed the merits of pigeonpeas, crotalarias, and Black Mauritius velvetbeans for green manure. Of the crotalarias, *C. juncea* is the most suitable for short-time growth (2 to 3 months), and *C. anagyroides* for a longer period (4 to 8 months). *C. spectabilis* and *C. striata* are intermediate in time of maturity. Both crotalarias and velvetbeans are considered to be resistant to the root-knot nematode (*Heterodera radicicola*), and are therefore very suitable for use in rotations with vegetable crops.

At the higher elevations, above 2,000 feet, the blue lupine (*Lupinus angustifolius*) and several species of *Vicia*, particularly purple, hairy, and Calcutta vetch, have given good results.

Of 10 different kinds of legumes planted for cover and green-manure crops in the coffee orchards in the Kona district, birdsfoot trefoil (*Lotus* sp.) alone appeared to offer any considerable promise.

It is readily propagated by cuttings in regions having plenty of rain, and makes a dense ground cover 6 to 12 inches high. Seed of this legume is not obtainable in Hawaii at present, but sets freely in some places on the island. Seed of *Lotus corniculatus* and of *L. major*, introduced from Australia, have been found to produce plants of greatly inferior growth as compared with the locally grown birdsfoot trefoil.

GRASSES

GRASS GARDENS

Grass gardens have been established on four ranches on the Island of Maui in cooperation with the agricultural extension division of the University of Hawaii and the ranch owners or managers. These gardens include plantings of about 40 species of grasses and varieties of legumes in pure stands and some pasture mixtures. Adaptation trials at the Haleakala substation, Makawao, island of Maui, where somewhat larger plats are under observation, show the importance of elevation in the establishment of many tropical, subtropical, and Temperate Zone species. Above 4,000 feet the following have shown considerable promise: *Lolium perenne*, *L. subulatum*, *L. multiflorum*, *Bromus unioloides*, *Dactylis glomerata*, *Phalaris tuberosa*, and several species of *Trifolium*, *Vicia*, *Melilotus*, *Festuca*, and *Agrostis*. Between 2,000 and 4,000 feet the promising kinds are *Pennisetum clandestinum*, *P. purpureum*, *Chloris gayana*, *Paspalum dilatatum*, *Phalaris tuberosa*, *Dactylis glomerata*, *Lolium perenne*, *Cynodon dactylon*, *Vicia villosa*, and *Trifolium pratense*. At the lower elevations the outstanding grasses and legumes are *Chloris gayana*, *Paspalum dilatatum*, *Panicum purpurascens*, *Panicum maximum*, *Pennisetum purpureum*, *P. clandestinum*, *Cynodon dactylon*, *Cajanus indicus*, *Melilotus alba annua*, *Meibomia uncinata*, and *Medicago sativa*.

Bimonthly harvests of a series of grasses in the four grass gardens established on the Parker ranch, Hawaii, in 1932, were made throughout the year. Samples of six species from each of the four gardens will serve as a basis for comparison of the effect of location on chemical composition. Direct comparison of the different species grown under similar conditions will be possible from analyses of species from the same garden. In addition to the perennial species, samples of the seasonal growth of bromegrass, ryegrass, mesquit, and the clovers are being analyzed.

YIELDS OF LARGE GRASSES

Napier grass (*Pennisetum purpureum*), Merker grass (*P. purpureum*), Sudan grass (*Andropogon sorghum sudanensis*), and guinea grass (*Panicum maximum*), grown under irrigation and cut and fed as soiling crops to dairy cattle, were compared as to yield. A crop of pigeonpeas and mixed legumes was plowed under before the grasses were planted, but no commercial fertilizer was applied to the area. Yields during the first year of the test were very satisfactory, the guinea grass with an acre yield of 11.08 tons, air-dry basis, slightly outyielding the other grasses. Napier grass was second with 10.88 tons, Sudan grass was next with 10.1 tons, and Merker grass was last with 7.97 tons per acre. There was no significant difference between the yields of guinea, Napier, and Sudan grasses. At the end of the year the Napier grass was in very good condition. After one or two cuttings, the Sudan and guinea grasses decrease sharply in yield, whereas the Napier and Merker grasses continue to give large yields.

COMPETITION OF GRASSES

A study of the competition of several grasses under conditions of low rainfall and low elevation was begun. Ten plats were planted with cuttings, each plat consisting of alternate rows of two grasses, all plants spaced about 2 feet apart each way. Timely observations are to be made on the aggressiveness of each grass and to determine if any of them eventually replace some of the others. The plats include the following combinations: Rhodes and Giant Bermuda grasses, Rhodes and kikuyu grasses, Rhodes and *Paspalum dilatatum*, Rhodes and *Panicum purpurascens*, Giant Bermuda and kikuyu, Giant Bermuda and *Paspalum dilatatum*, Giant Bermuda and *Panicum purpurascens*, kikuyu and *Panicum purpurascens*, kikuyu and *Paspalum dilatatum*, and *P. dilatatum* and *Panicum purpurascens*. All plats were seeded as well with Spanish clover (*Meibomia uncinata*) to determine whether this legume can maintain itself among these vigorous grasses.

MINERAL COMPOSITION AND NEEDS OF PASTURE GRASSES

In cooperation with the agricultural extension division of the University of Hawaii, samples of pasture grasses were collected from 10 different localities on the island of Hawaii to determine their mineral composition. The plats on which grasses grew were fertilized at the acre rate of 1,000 pounds of limestone, 300 pounds of superphosphate, and 100 pounds of potassium sulphate, followed a year later by 300 pounds of ammonium sulphate. The results showed a strong increase in the percentage of lime and phosphate in the fertilized grasses from Waipahoehoe and the Volcano plats. In the other cases there were no significant differences in the composition of the grasses from the fertilized and unfertilized areas. The increases in lime and phosphate content of the fertilized Waipahoehoe grasses remained undiminished 18 months after the initial application. There was also an appreciable increase in the amount of growth.

In all of the 10 locations the results of the nitrogen fertilization were disappointing. Dry weather may have been partly responsible, but the fact remains that no such increase in growth resulted as would have been the case with a cultivated crop. In areas near the quadrats plowing and disking invariably gave rise to remarkable stimulation of growth with no fertilization. For the purpose of increasing total growth, tillage is thought to be far more effective than top-dressing. Only when there is a marked deficiency of an element, as is the case at Waipahoehoe, does top-dressing have any great effect on the quantity of growth.

The generally negative results from top-dressing have several plausible explanations: Symptoms of severe mineral deficiency are not recognized on Hawaiian ranges except in a few localities. Many of the ranches have excellent soils and are seldom heavily stocked.

Experience with cultivated crops has shown that small applications of phosphate fertilizer often give no response, due to the fixing power of the soil for phosphates, whereas large applications, such as 800 to 1,200 pounds of superphosphate, give economic increases. From the practical standpoint of the rancher, such applications could not be considered. It has also been found that phosphates are fixed so rapidly by the soil that when applied to the surface of the soil they often remain in the first inch or two of the soil and are thus inaccessible to most of the plant roots. Application of fertilizer at the time of plowing appears to offer the best possibility of increasing both the quantity and the quality of forage. Experiments are being planned with this in view.

GRASS AND FORAGE-PLANT INTRODUCTIONS

Introductions of forage plants included 47 samples of grass and 50 samples of legume seeds. The plants are being tested for adaptability to conditions at the central station in Honolulu and on various ranches on the outlying islands.

TREE KALE

One of the most promising forage plants introduced during the year is the marrow-stemmed tree kale or chou moellier (*Brassica oleracea acephala*), which is apparently adapted to the subtropical conditions of Hawaii and grows well throughout the year. From seed obtained from Australia and planted at the station in December 1932, a total green weight of 32 tons per acre, equivalent to an acre yield of 550 pounds of green weight per day, was obtained when the leaves were harvested in February, March, April, and May. Experiments are being made to determine the value of this plant as a green feed for poultry (p. 22). It is highly valued as a feed for swine and for dairy cattle in Australia, but the station has not tested its value for these kinds of livestock.

FRUITS, VEGETABLES, AND NUTS

CITRUS

The experimental citrus orchard, started in 1905, has been gradually extended to cover about 2 acres and contains numerous species and varieties. It is maintained for cultural tests of varieties and as a source of propagating material. During the year 13 grafted trees of the Siamese seedless pomelo, originally received from the Bureau of Plant Industry, United States Department of Agriculture, were set out on the station grounds. One of the most interesting developments of the year was the fruiting of several trees of the mandarin orange. The crop matured without attack by the Mediterranean fruit fly, and the prolificness of the trees and the high quality of the fruit indicate its commercial possibilities in Hawaii. Seedlings of the Cleopatra mandarin were produced for use in rootstock variety experiments. Certain phases of the citrus work are being carried on at the Kona substation, where conditions are quite different from those at the central station at Honolulu. During the year the station citrus orchard was utilized for fruit-fly investigations by the Bureau of Entomology of the United States Department of Agriculture.

AKALA OR NATIVE RASPBERRY AND OTHER RUBUS SPECIES

The distance of Hawaii from the mainland markets is so great as to make it impracticable to import either raspberries or blackberries in the fresh state. To remedy this condition studies were continued to promote the development of the two local species of raspberry for growth on a commercial scale. The fruits of these species are extraordinarily large, 1 to 1.5 inches in diameter, but are somewhat too tart for ordinary table use. Attempts are being made to hybridize these species with the best-flavored varieties from the mainland and from elsewhere. The variety test with various species of the genus *Rubus* have included North American varieties of both the red and blackcap raspberries, blackberries of evergreen and thornless varieties, dewberries, plants of *R. niveus* from the Philippines, *Rubus* sp. from Java, and *R. rosaefolius*, an insipid but locally well-adapted species of possible value for hybridizing.

POTATOES

Ten varieties of potatoes were tested for yields at the Haleakala substation, Makawao, island of Maui, and in cooperation with the experiment station of the Pineapple Producers Cooperative Association at Wahiawa, island of Oahu. In the Maui tests the highest yields were obtained with British Queen, White Rose, Earliest of All, and Burbank. At Wahiawa, the best yields were obtained with Irish Cobbler, British Queen, Triumph (Bliss Triumph), and Garnet Chili. These tests showed the source of the seed stock to be an important factor in producing high yields. Certified seed is essential, particularly in the warm climate of Hawaii where insect pests and virus and fungus diseases spread rapidly. Variety tests are significant only if the seed used comes up to the same standard in each variety and little significance should be attached to 1 year's results in testing varieties.

The production of seed potatoes was begun in cooperation with the agricultural extension division of the University of Hawaii and with the Parker ranch at Kamuela, island of Hawaii. Three acres of Triumph potatoes are being grown from certified seed from Nebraska. These plantings will be inspected and rogued for diseased and weak plants and an effort will be made to produce clean seed for the fall plantings. The potato plats are located at elevations ranging from 4,500 to 5,500 feet, and are isolated by several miles in all directions from other potato fields.

In cooperation with the agricultural extension division of the University of Hawaii, a series of field experiments was undertaken to determine the fertilizer requirements of potatoes. Three of the large pineapple companies and the experiment station of the Pineapple Producers Cooperative Association cooperated in these experiments on lands previously planted with pineapples. Each element was tried in three different quantities, ½, 1, and 1½ times the amount carried by the standard fertilizer, the other two elements remaining constant. The standard fertilizer treatment used was 2,000 pounds per acre of a 4:12:8 mixture. Five experiments were carried out, 2 on Oahu and 3 on Kauai (fig. 1).

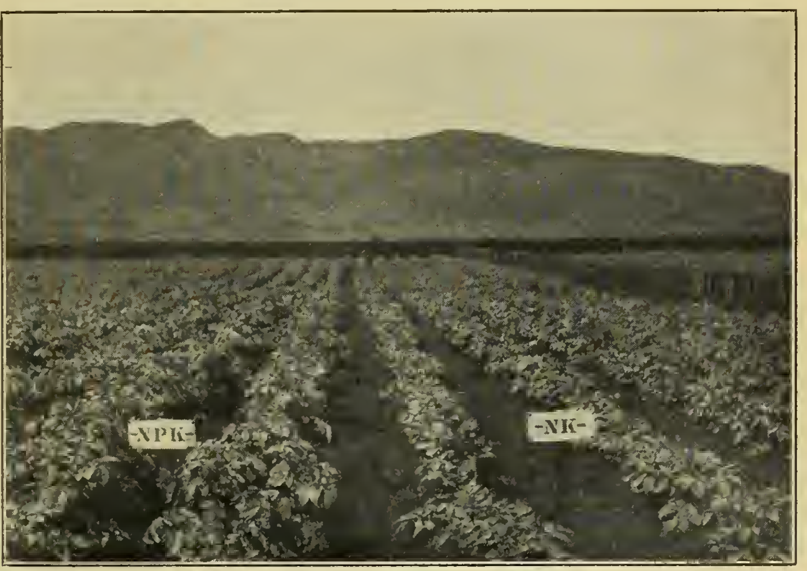

FIGURE 1.—Fertilized plats of potatoes at Wahiawa, Oahu, showing marked response to phosphate as compared with plats receiving the same amounts of nitrogen and potash but no phosphates. Two of the experiments were made on Oahu and three on Kauai.

A series of pot tests, using both Sudan grass and potatoes as indicators, were made and the results correlated with those of field experiments (fig. 2). The potatoes were grown in soya tubs with three plants to a pot, using the same soil as in the field experiments. The fertilizer application per pot was at the same rate as one hill received in the field experiments. Heavy rains, destructive

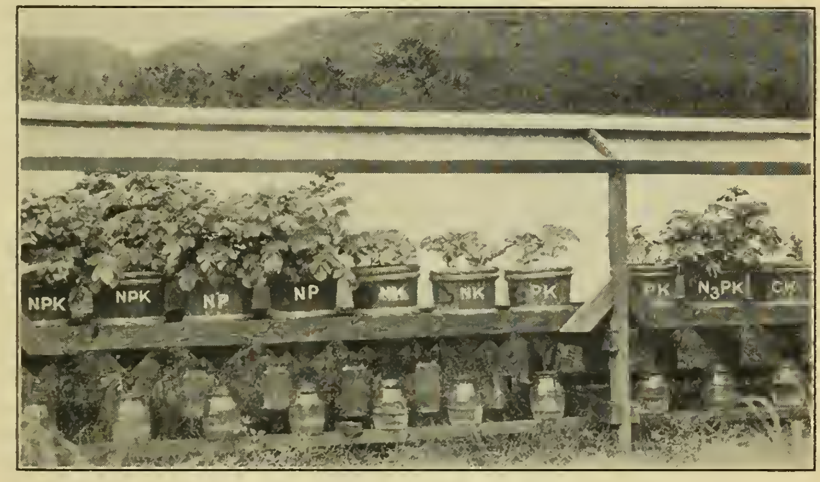

FIGURE 2.—Pot tests with potatoes.

winds, and poor germination tended to create a high experimental error, but the effects of fertilizer were so striking that significant increases resulted in all cases from the use of phosphates. Two of five experiments showed significant increases from the use of nitrogen and one gave significant response from potash. It was concluded that except for potash-deficient areas a formula of 6:12:4 would give best returns for potatoes.

Excellent correlations between the results of the potato pot tests and the field experiments were obtained when the plants in the pots were kept free from disease. With proper control over disease and pests, the pot method offers excellent promise as a means of indicating the needs of the soil for potatoes.

SWEETPOTATOES

Ninety-seven varieties and strains of sweetpotatoes were grown in small plats. A large number were discarded because of small size, poor yields, and inferior quality. Fifty varieties were included in further plantings for a more thorough study of their adaptation and yielding ability. Several new varieties were introduced from the Suhum substation, Caucasus, Union of Soviet Socialist Republics, through courtesy of Dr. Alekseev. At least one of them, Accession no. 2584, appears to be of very good table quality and it will be increased and tested more extensively. A new variety, introduced from Tahiti through the courtesy of G. P. Wilder, yielded well in a preliminary test and will be further propagated.

TABLE CORN

Guam white corn has become popular in Hawaii not only as a field corn but also for table use. Although it is not a sweet corn it possesses fairly good flavor if used at the proper stage. Its outstanding value, however, is probably its ability to withstand heavy infestations of the corn leaf hopper (*Peregrinus maidis*). Most mainland varieties when planted in Hawaii become severely infected with corn stripe or mosaic, which is probably transmitted by the corn leaf hopper from diseased to healthy plants. The Guam variety seems to be little affected with corn stripe as compared with most of the mainland varieties.

Two new varieties of sweet corn, Surcropper Sugar and Honey-June, were introduced from the Texas Agricultural Experiment Station. The plants in the first two crops grown in Hawaii were not badly infected with the corn-stripe disease. A subsequent planting, however, showed a heavy infection and it is felt that these varieties have little or no resistance to this disease.

CABBAGE

Twenty-one varieties of cabbage were tested for yields, heading characteristics and adaptability at the Pensacola Street station, and also in cooperation with the agricultural extension division of the University of Hawaii in the Volcano district, island of Hawaii. At Honolulu the varieties giving the highest yields were, of the early ones maturing in 90 to 110 days, All Head Early, Midseason Market, Early Jersey Wakefield, and Golden Acre; of the midseason varieties maturing in 110 to 125 days, Succession, Volga, Hollander, and Charleston; and of the late varieties maturing in 125 to 140 days, Late Flat Dutch and Improved American Savoy.

In the Volcano district of Hawaii the most promising varieties in the year's test were Marion Market, Midseason Market, Early Dwarf, Flat Dutch, and Round Red Dutch.

Pot tests and field tests of cabbage were made. The regular Mitscherlich pots, holding about 4.2 kilos of soil, were used for cabbage as well as for Sudan grass. Preliminary tests in which the number of cabbages was varied from 1 to 6 to a pot showed that the most satisfactory results were obtained with 3 plants to a pot. When planted at this rate the cabbages did not head to any extent, but grew vigorously to the heading stage, when they were harvested.

The Volcano and Waimea districts, island of Hawaii, were included in these cabbage tests. The tests indicate an excellent correlation of pot and field results. Cabbage was shown to be particularly sensitive to nitrogen and phosphate deficiency.

LETTUCE

The most promising station head-lettuce hybrids were grown and studied for uniformity and heading characteristics. A selection made in 1932 from a variety known as Accession no. 1801 showed considerable promise of becoming a desirable strain for the lower elevations. Nearly all of the plants headed well and the lettuce was of fine flavor. The variety is a hybrid having in its ancestry the varieties Los Angeles Market, Los Angeles White, and All Seasons. All Seasons is a variety of the butter-head type.

Several crosses between the most desirable hybrids and Mignonette were made. The difficulty formerly experienced in getting Mignonette to seed was overcome largely by cutting the heads open immediately after they were well formed.

MISCELLANEOUS CROPS

Miscellaneous variety tests included 50 varieties of taro (*Colocasia esculenta*), 14 varieties of cassava (*Manihot esculenta*), 8 varieties of edible canna (*Canna edulis*), 5 varieties of garden beans, 4 varieties of tomatoes, 3 varieties of sesame (*Sesamum indicum*), and 3 varieties of peanuts (*Arachis hypogaea*).

MACADAMIA NUT

Interest in local Macadamia-nut production increased during the year largely as a result of the coming into bearing of many of the younger trees (fig. 3), and the perfecting of a nut cracker especially adapted to the Macadamia nut. With every promise of a rapidly increasing crop, and with the cracking, dehydration, and roasting processes worked out, exportation of the finished product is becoming a reality.

The lines of work previously begun with this crop were maintained. Testing of the quality of nuts from outstanding trees in different localities was continued, many of the young trees just coming into bearing being included so as to permit recording of an ample number of superior trees for subsequent budding and grafting. It becomes increasingly evident that the quality of nuts from a given tree is considerably affected by such factors as season, cultural practices, and the size of the previous season's crop. The records of a tree should therefore be kept over a period of years to be of the greatest use.

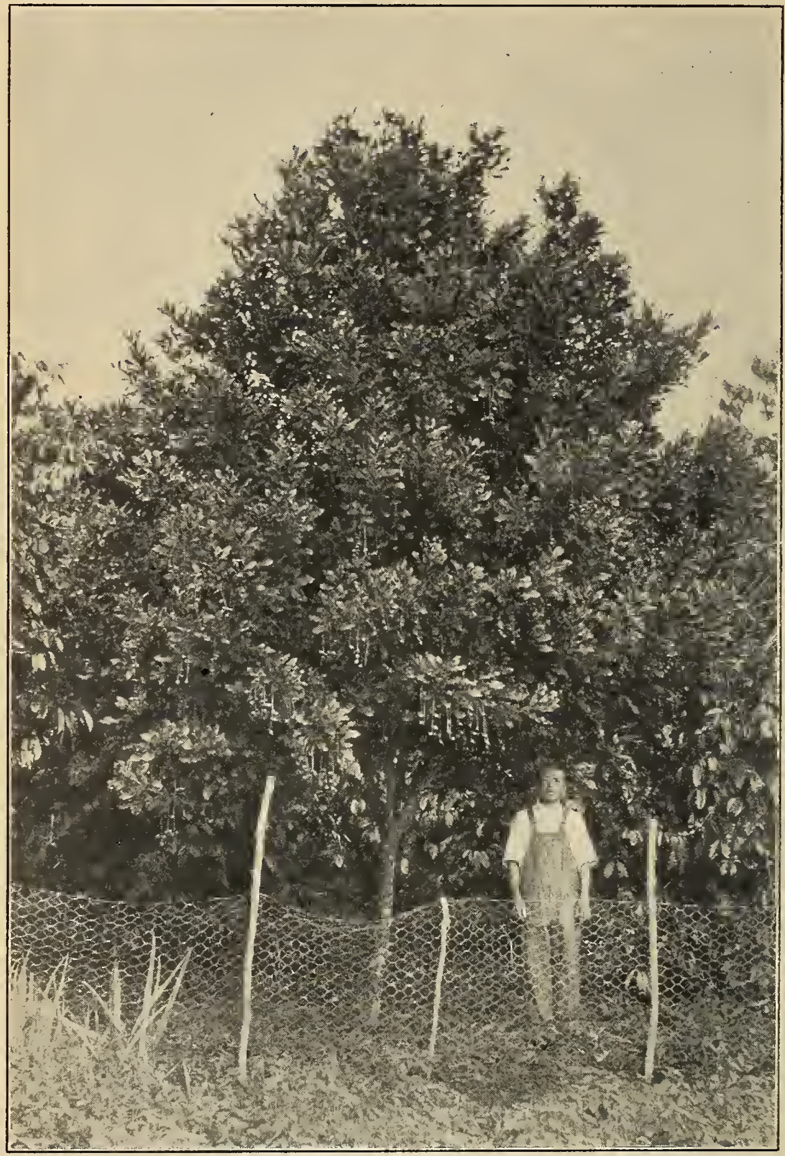

FIGURE 3.—A 6-year-old Macadamia-nut tree in Kona, Hawaii. Note the heavy set of nuts.

The importance of more exact knowledge of the cultural and nutritional requirements of the Macadamia is becoming apparent. Records from one grove showed a very marked decline in quality of nuts as compared with those of the previous year, apparently as a result of poor management in irrigation, pruning, and fertilization. The trees often develop malformed chlorotic leaves, which is indicative of nutritional disturbances. Cooperative field experiments were begun in Kona, island of Hawaii, to determine the effect of a wide range of fertilizer treatments on growth and set of nuts. A large quantity of soil from the main grove of a local Macadamia nut company was shipped to the central station, and pot tests to determine the effect on Macadamia seedlings of various soil amendments, such as iron, zinc, copper, manganese, magnesium, boron, and calcium, were begun.

Further investigations on the storage and processing of Macadamia nuts has demonstrated that nuts in the shell, kept under ordinary air-dry conditions, become rancid in from 8 to 12 months. They are also likely to mold and to become infested with weevils. When cracked and dehydrated, they may be kept in airtight containers for a longer time. Storage experiments were begun in which the nuts were cooked in a number of different vegetable oils, and oven-roasted and packed in vacuum and nonvacuum containers. The nonvacuum samples showed no deterioration for 2 months. Of the vacuum tests, the samples cooked in oil had a slightly off flavor and odor after 6 months, whereas the roasted samples showed no off flavors or odors. It becomes increasingly evident, however, that whereas rancidity and off flavors may be prevented easily, the delightful flavor and aroma characteristic of fresh nuts, just cracked and freshly roasted, are maintained with difficulty. This same difficulty is experienced with the pecan and the roasted almond.

Macadamia trees throughout the islands now number about 18,000. The great variation in nuts grown on seedling trees makes it practically impossible to standardize the crop, as will be necessary if the nut is to assume its rightful place in the market. The young seedling trees are difficult to bud and graft, and up to the close of the year the percentage of successful grafts was very low. However, the grafting of nursery stock at the Kona substation has been 40 percent successful, indicating the possibility of grafting on a large commercial scale. A number of remarkably good seedling trees have been located for use as a source of bud wood in standardizing the crop.

ORCHARDS AND ARBORETUM

The station orchards and economic tropical arboretum, now in the third year, contain numerous species and varieties of promising tropical fruits, nuts, and berry plants with which the cultural requirements, best methods of budding and grafting, and the commercial and home-utilization possibilities are being worked out. Plantings have been made at elevations varying from 50 to 6,000 feet. Definite progress has been made with the following kinds: Avocado (*Persea americana*) (fig. 4), allspice (*Pimenta officinalis*), bananas (*Musa* spp.), Brazil cherry (*Eugenia dombeyi*), breadfruit (*Artocarpus incisa*), cherimoya (*Annona cherimola*) (fig. 5), carissa or Natal plum (*Carissa grandiflora*), coconut (*Cocos nucifera*), cashew nut (*Anacardium occidentale*) (fig. 6), date (*Phoenix dactylifera*), fig (*Ficus carica*), guava (*Psidium guajava*), litchi (*Litchi chinensis*), mabolo (*Diospyros discolor*), mamey apple (*Mam-*

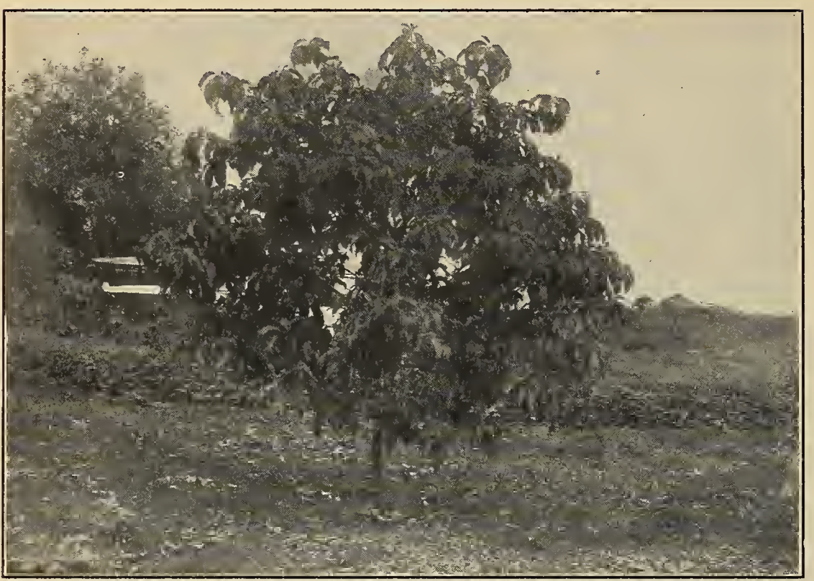

FIGURE 4.—Guatemalan avocado tree of the Nabal variety at the Kona substation. Set as a 1-year-old graft in April 1930 and photographed 2 years later.

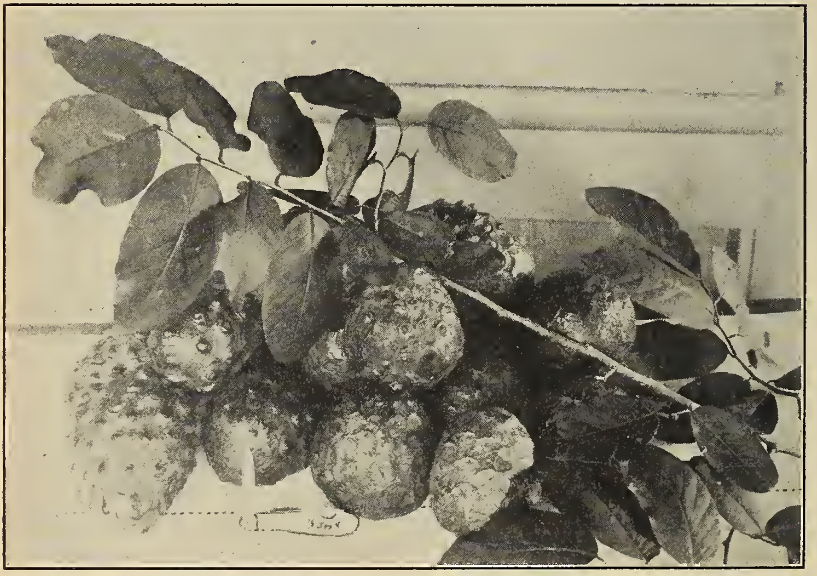

FIGURE 5.—The cherimoya fruits best in a cool, semidry region where frost does not occur.

mea americana), mango (*Mangifera indica*), mangosteen (*Garcinia mangostana*), mountain apple (*Eugenia malaccensis*), mullberry (*Morus nigra*), olive (*Olea serrata; O. europaea*), papaya (*Carica papaya*), poha (*Physalis peruviana*), pejibaye palm (*Guilielma utilis*), pili-nut or canary-nut (*Canarium ovatum; C. commune*), passion fruit (*Passiflora* spp.) (fig. 7), persimmon (*Diospyros kaki*), sapucaia (*Lecythis zabucajo*), and vi-apple (*Spondias cytherea; S. tuberosa*).

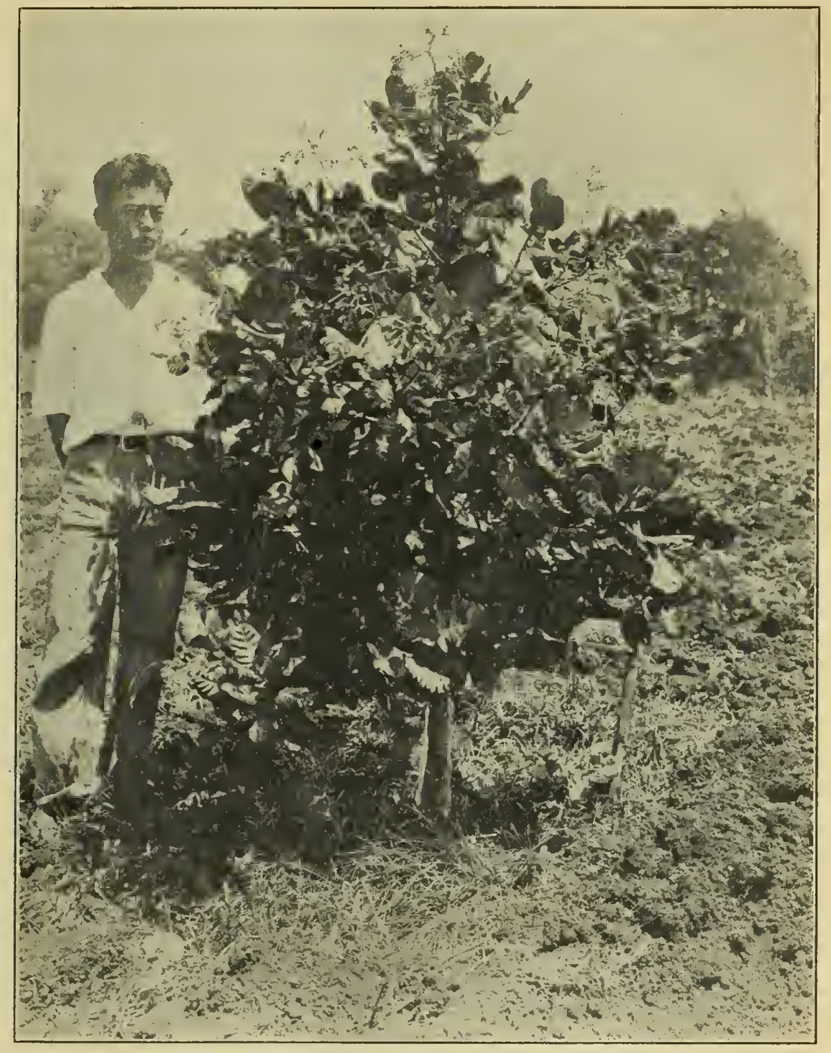

FIGURE 6.—The cashew-nut tree is of easy culture.

COFFEE

VARIETAL, CULTURAL, AND PROPAGATION STUDIES

Investigations with coffee included varietal, cultural, and propagation studies at the central station in Honolulu (altitude 50 feet), at the Tantalus substation (altitude 1,000 feet) near Honolulu, and at the Kona substation (altitude 1,500 feet), island of Hawaii. A total of 1,076 young coffee trees, including both Arabian and Liberian types, are under test. A large number of seedlings (*Coffea arabica*, *C. robusta*, and *C. liberica*) for use as rootstocks and for hybridizing work were grown during the year. It is believed that the coffee industry will be materially assisted by the development of a superior high-yielding strain that can be grafted on very resistant stock. At present the local crop is produced entirely from seedling trees rather than from grafted trees of superior quality, yield, and resistance to diseases and insect enemies.

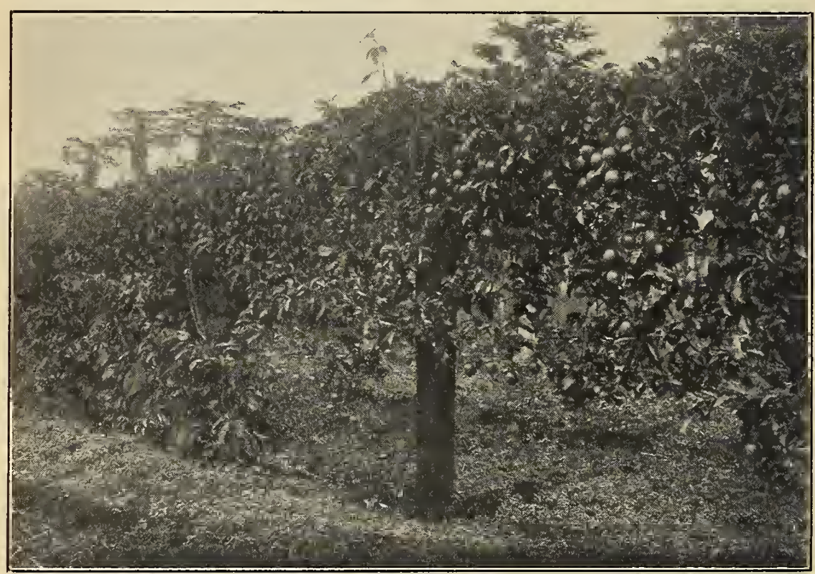

FIGURE 7.—Passion fruit growing on trellis. In cultivation at the Kona substation.

EXPERIMENTS IN HAMAKUA

Experiments begun in 1930 to determine the best methods of rejuvenating old coffee plantings in the Hamakua district were continued. Both seedlings and new verticals from old stumps have produced a moderate crop. Under these two methods there was a loss of two complete crops and part of another. Heavy pruning caused a loss of one and one-half crops, whereas moderate pruning resulted in the loss of only one crop. The latter produced a remarkable growth of new wood that had to be drastically thinned to prevent immediate return to the "umbrella effect" and consequent shading out of all inside growth.

Pot tests of this Hamakua coffee soil and observations on the fertilized and unfertilized areas showed the soil to be unusually fertile despite the fact that it had not been fertilized for many years. This is undoubtedly due to the heavy growth of the silk-oak (*Grevillea robusta*) which is used as a shade tree. The leaves and branches dropping from it together with the leaves and the trash from the coffee tree have created almost virgin forest conditions and the relatively light crops of coffee have not caused any appreciable drain on the plant food reserve in the soil. If good coffee yields are to be had in this district the trees should be systematically pruned and thinned each year, and shade should be carefully controlled. Moderate fertilizer applications should also be made, especially on the poorer soils.

EXPERIMENTS IN KONA

A pot test of soil from the Kona coffee-fertilizer experiment with Sudan grass as the indicator crop showed a very striking lack of phosphoric acid and nitrogen with an abundance of potash. The field test, however, showed a pronounced response to potash and very little response to phosphorus. The pot experiments, using coffee seedlings as the indicator crop, correlated with the Sudan-grass experiment. This apparent contradiction is probably due to difference in the plant-food requirements for vegetative growth as compared with cherry development.

Results of the 1932–33 harvest of the Kainaliu fertilizer experiment showed outstanding differences between treatments. The check, nitrogen only, and nitrogen-phosphorus plats produced 17, 21, and 27 bags, respectively, of cherries per acre, whereas the nitrogen-potash and nitrogen-phosphorus-potash produced 113 and 120 bags, respectively. In the absence of any appreciable crop in the former group, new growth has developed. To what extent fruit will set and mature remains to be seen. In contrast with these field results, pot tests at the central station in Honolulu, using soil from the same experimental field and coffee seedlings of the same variety, showed marked response in the vegetative growth of the seedlings to phosphorus, but little response to potash. The plant-food requirements of a bearing tree and of a young nonbearing seedling may thus be considerably different.

Studies on Kona soils showed them to have a high water-holding capacity, which is rather characteristic of ash soils in moist regions. The soils tested have shown a low nitrogen content and a high phosphate-fixing power. These properties of coffee soils without shade are in marked contrast with those of the Hamakua coffee soils.

The experiment to determine plat variability in yields with uniform fertilizer treatment was concluded at the end of the third crop, and showed that, under ordinary pruning methods, the yield of a single tree or of a plat of nine trees has little significance unless the experiment is carried over a long period. Excessive production in one year followed by die-back in the next caused the yields on a single plat to drop from 400 pounds in one year to 35 pounds in the next. With the pruning system used in a large part of Kona, very little of the coffee tree is permanent wood. Except for the stump and for some short scaffold branches, the entire tree is pruned. In most of the privately owned orchards no two trees are pruned exactly alike, nor is an equal proportion of the total growth removed each year. All these factors cause the individual tree or the plat to be a variable entity, not at all well adapted to the measurement of the effect of one factor, such as fertilizer.

The potential value of coffee pulp as a compost for the coffee fields of Kona has led to an intensive study of the best methods of composting. The experimental compost pit at the Kona substation was filled with fresh pulp in October 1932. When the mass was not turned, decomposition proceeded very slowly, but when turned once after 3 months it decomposed sufficiently for use as manure by May 1933, 7 months later. Through the efforts of the agricultural extension division of the University of Hawaii about a dozen Kona farmers have established compost pits, adding to the pulp limestone, superphosphate, and ammonium sulphate as prescribed by the station. Samples of these various composts, together with samples of pulp, of fermentation liquors, and of the coffee cherries from various localities have been collected and are being analyzed for general study of the amount of plant-food elements removed by the coffee crop and the amount recoverable for return to the soil.

An experiment has been started to determine the feasibility of systematizing the pruning procedure, whereby each tree is made to conform to a definite pattern by the yearly removal of a definite number of verticals from each tree and by forcing out a definite number of new verticals. Two methods are being tried to force out verticals when and where desired. In one method the old vertical is cut off to force the development of the new shoots. In the other method the old vertical is left intact, but the bark is girdled near the base to induce new shoots to develop there.

Comparative studies of four different methods of preventing dieback in coffee were begun. In three of these the amount of bearing is reduced by removing primary laterals, pruning back laterals, and breaking off blossom clusters. In the fourth method the verticals are girdled in the spring. While these experiments have been primarily a study of plat technic, they may prove to be of value as applied to present practices. A very careful balance of the price of coffee, the amount of fertilizer used, and the amount and kind of pruning seems to be desirable.

ANIMAL PRODUCTION

DAIRY

The opinion held by many dairymen in Hawaii that the feeding of protein up to 50 percent in excess of the amount recommended by the Morrison feeding standard is desirable or necessary for heaviest milk production was not confirmed in experiments with dairy cows.

Green pigeonpea tops with attached immature pods were found to be worth somewhat more, pound for pound, than green alfalfa as a feed for dairy cows, although the alfalfa proved to be the more palatable.

Pineapple bran as a supplement to concentrates and roughages was shown to be as good as beet pulp as a feed for dairy cows, and, at prices obtaining in Hawaii, it resulted in a material saving in feed costs.

In continuation of experiments begun in 1924 to learn the value for dairy cows of feeding a concentrate mixture containing 25 percent of sugarcane molasses, molasses-fed cows were found to produce as well as nonmolasses-fed cows. In a long-time test, covering 7 years of molasses feeding, nonmolasses-fed cows produced about 4 percent more butterfat and maintained a somewhat better reproductive efficiency than molasses-fed cows.

Experiments in feeding sprouted oats to animals exhibiting irregularity in breeding behavior indicated that, under Hawaiian conditions, with green feed available the year around, sprouted oats have little value in correcting such troubles in dairy cows.

SWINE

Results of feeding bananas and papayas to swine in places distant from market where cull fruits cannot be sold to advantage, indicated that these fruits have considerable value for the fattening of hogs particularly, but are worth materially less than is barley. Bananas are worth more than papayas.

Sugarcane molasses was found to be worth as much, pound for pound, as barley for producing gains when fed up to 20 percent of the concentrate mixture to hogs having an initial weight of 50 to 100 pounds. The saving in feed cost varied, depending on the relative prices of barley and sugarcane molasses, but, in general, under prices prevailing in Hawaii it amounted to about 20 percent when 20 percent of the molasses was included in the concentrate rations fed swine.

Sprouted oats were more effective with sows than with cows having breeding troubles, possibly because swine get materially less green feed. While all the sows fed sprouted oats were not benefited, their records as a whole were better than those of an equal number of controls also having breeding troubles but not fed sprouted oats.

POULTRY

FOWL-POX CONTROL IN BABY CHICKS

The results of investigations begun in 1927 to determine the method of transmission of fowl pox or "sorehead", contagious epithelioma, to chicks, turkey poults, and squabs, and the efficiency of a "live virus" vaccine in developing immunity against the disease, indicated that the disease is carried to chicks by the mosquito, and that chicks 4 to 12 weeks old and poults 3 to 16 weeks old may be successfully vaccinated. In cooperative field trials over 60,000 chicks have been vaccinated with a mortality of about 5 percent.

RAISING TURKEYS IN CONFINEMENT

Experiments carried on for 3 years have indicated that turkeys may be raised economically in close confinement under semitropical conditions if the poults are vaccinated against fowl pox. A vaccine has been made that develops immunity in poults as early as the sixth week if they are vaccinated at the age of 3 weeks. The mortality under this system has been less than 5 percent up to the market age of 9 months.

SUGARCANE MOLASSES AS A POULTRY FEED

In an experiment continued for 3 years chick and growing rations containing 5 and 7 percent of sugarcane molasses have given good growth and economical gains. In fattening rations 10 to 15 percent of the molasses was found to give economical gains and a product of good quality.

TREE KALE FOR POULTRY

In comparative tests of tree kale and alfalfa as sources of green feed for poultry, the results indicated a more uniform rich yolk color from tree kale than from alfalfa. Egg production, fertility, hatchability, and body development were practically the same for both green feeds. Tree kale is one of the promising forage plants introduced during the year (p. 9).

HATCHING CHICKS THROUGHOUT THE YEAR

In an attempt to utilize brooding equipment to better advantage, eliminate periods of surplus, and maintain a constant price throughout the year, it was found that chicks grew normally regardless of time of hatching, but that fertility was low during June and July when the same breeding males were used over a period of 8 months. By placing new males in the pens fertility was restored to normal. Hatchability of fertile eggs was good and the chicks came through with a mortality of less than 7 percent up to 6 months of age. Further work is to be done before the practice is recommended for general use.

EFFECT OF RELATIVE HUMIDITY ON HATCHABILITY

Experiments have been made to determine the relationship of humidity to hatchability of eggs and weight of chicks, but further work on the subject is necessary before recommendations can be made that will be applicable to all sections of the Territory.

BATTERIES FOR LAYING AND BREEDING STOCK

In the first attempt made in Hawaii to house laying hens in batteries, one half the birds were fed daily a fermented yeast mash containing 1 percent of yeast. The production for the first 7 months averaged 66 percent without artificial illumination. During this period three birds died. At 7 months the birds were wormed, resulting in the elimination of hundreds of roundworms. The birds receiving the fermented yeast mash gained more in weight than those receiving none, but there was no apparent advantage in egg production.

ARTIFICIAL ILLUMINATION FOR LAYING HENS

Pullets hatched in November, December, January, and February have a tendency to molt in whole or in part before a full year of laying. All-night illumination was tried on early-hatched pullets, and lighting begun at 4 a.m. was used on another group. Hens under all-night illumination showed complete molt when the lights were gradually removed, whereas those under the 4 a.m. lighting showed a slight partial molt and a slight decrease in egg production. The yearly egg production per bird under both systems showed an increase over that of birds receiving no light. Body weight was well maintained under both systems and the mortality in each group was practically the same.

FOODS AND NUTRITION

IODINE CONTENT OF SOME HAWAIIAN FOOD PRODUCTS

Results of investigations undertaken to establish the iodine content of Hawaiian-grown vegetables and other food products are shown in the following tabulation:

Sample:	*Iodine content of dried material (parts per billion)*
Avocado oil	8,085
Burdock	154
Beets no. 1	167
Beets no. 2	446
String beans	1,420
Mustard cabbage	725
Head cabbage	791
Cucumbers	334
Carrots	548
Celery	623
Daikon	7,698
Fish powder	936,000
Ginger	323
Lotus	1,710
Lettuce	598
Opihi (shellfish)	4,475
Bell peppers	328
Chinese peas	434
Pineapples	1,070
Poi	318
Potatoes no. 1	142
Potatoes no. 2	162
Sweetpotatoes	70
Spinach	2,023
Squash	608
Tomatoes	203
Yams	173
Limu (lipeepee)	58,800
Limu (manauwea)	15,800
Limu (lipoa)	292,000

The data indicate that Hawaiian food products contain sufficient iodine to meet the needs of normal animal metabolism, comparing very favorably in this respect with food products grown in various parts of the United States. These figures are higher than the average of results obtained for the same products grown on the mainland.

STEROL CONTENT AND VITAMIN VALUE OF AVOCADO OIL

In the report of the station for 1931[2] a method was outlined for obtaining pure avocado oil in quantity and for isolating the sterols. Some preliminary experiments on the isolation of sterols from the oil were described. The object of the work here reported was to isolate pure sterols from avocado oil in sufficient quantity to investigate them chemically and to establish their connection with the nutritional value of the oil.

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[2] BILGER, L. N., YOUNG, W. Y., and ROBBINS, R. C. REPORT OF SPECIAL AVOCADO CHEMICAL INVESTIGATIONS. Hawaii Agr. Expt. Sta. Rpt. 1931: 15. 1932.

It was found essential, in preparing sterols, to use oil that had been expressed by a mechanical process only and that had not been treated by any process for the elimination of its bitter principle. The method developed for preparing comparatively good yields of pure sterols differs from that previously described in that the oil was saponified completely and the sterols were extracted from the resulting soap mass by means of ethyl ether. The purified product consisted of lustrous, colorless crystals melting at 143°–144° C.

In an investigation with white rats to determine the vitamin value of the sterol from avocado oil and of the oil itself the following results were obtained: (1) Avocado oil, fed either as a supplement or as an included percentage of the diet, failed to cure or prevent ophthalmia in white rats. Qualitative tests confirmed the absence of vitamin A. (2) Both the sterol and the whole avocado oil, irradiated with ultraviolet light, exhibited strong antirachitic properties. (3) A study of the nutritional value of avocado oil compared with an ordinary vegetable oil showed the two to be approximately the same. Irradiation improved the power of both to promote growth.

VITAMIN B CONTENT OF FRESH DAIKON AND TAKUWAN

Continuing the study of the transfer of vitamin B from rice bran to plant tissue, which has been demonstrated by the nutrition laboratory of the station[3] as taking place during the salting of Chinese cabbage (*Brassica chinensis*) with rice bran, preliminary experiments were made on a root vegetable, the oriental radish or daikon (*Raphanus sativus longipinnatus*), which is pickled in a paste of salt and rice bran to make a product called takuwan. When fed to rats as the sole source of vitamin B, 8 grams of fresh daikon produced a gain of 11 grams in 8 weeks, whereas 3 grams of commercial takuwan caused a gain of 57 grams in 8 weeks. Inasmuch as 3 grams of the pickled product probably represent between 5 and 6 grams of the fresh material it is evident that the pickled product acquired vitamin B from the bran. Rats fed the inner portion of the daikon gained as much as those fed the same quantity of the outer portion, indicating that vitamin B penetrates to the very center of the radish.

COMPOSITION AND VITAMIN STUDIES OF GREEN SOYBEANS

Certain varieties of soybeans, called “ edamame ”, are used in the green state in Japan. Japanese in Hawaii use them in small quantities. The beans are boiled in water in the pods for about 25 minutes and are shelled as eaten or when used in food combinations.

Green soybeans of unknown variety bought in the open market and a variety, F.P.I. 80483, raised on the University of Hawaii farm were analyzed for organic nutrients, calcium, phosphorus, and iron. The results are shown in table 2.

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[3] MILLER, C. D., and ROBBINS, R. C. REPORT OF THE NUTRITION LABORATORY OF THE HOME ECONOMICS DIVISION. Hawaii Agr. Expt. Sta. Rpt. 1932: 18. 1933.

TABLE 2.—*Composition of green soybeans*

Material analyzed	Moisture	Protein	Ether extract	Crude fiber	Ash	Carbohydrates (by difference)	Calcium	Phosphorus	Iron
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Green soybeans, cooked [1]	64.2	15.0	2.7	1.6	2.9	13.6	0.100	0.267	0.00213
Do.[2]	63.5	13.8	4.2	1.5	3.1	13.9	.098	.286	.00344
Green soybeans, raw [3]	69.1	12.5	5.2	1.5	1.8	10.1	.063	.239	.00283

[1] Variety unknown. Purchased on the open market. 2 samples.
[2] Variety F.P.I. no. 80483. Grown at the University of Hawaii farm. 2 samples.
[3] Variety F.P.I. no. 80483. Grown at the University of Hawaii farm. 1 sample.

In experiments with rats cooked green soybeans proved to be a good source of both vitamin A and vitamin B. In preliminary vitamin G experiments a daily supplement of between 1 and 2 grams of the cooked beans resulted in a gain of 28 grams per week.

VITAMIN C IN FRESH PINEAPPLE JUICE AND IN GUAVAS

Fresh pineapple juice was tested with guinea pigs for vitamin C and found to have about half the antiscorbutic value of fresh orange juice.

Guava juice, extracted as for jelly making and canned for use as needed, was found to be as potent a source of vitamin C as fresh orange juice, as 3 cubic centimeters daily afforded protection for the teeth of guinea pigs. Animals fed 1 gram of the whole fresh guava, 11 percent of which was seed, showed no signs of scurvy at autopsy. The fresh guavas appear to be a better source of vitamin C than oranges.

VITAMIN D IN THE OPIHI

The vitamin D content of various parts of the Hawaiian shellfish, known as opihi (*Helcioniscus exerata* and *H. argentatus*), was studied by three methods: Chemical analyses for total ash and for calcium; X-ray pictures; and a histological examination known as the "line test." The line test was judged to be the most satisfactory. Four grams of whole opihi and 1 gram of the organs, sperm, and egg were found to be minimum amounts affording full protection against rickets.

ANTIANEMIA VALUE OF OPIHI

Further studies of the hemoglobin-regenerating value of opihi for anemic rats indicated that 2 to 4 grams daily as the only supplement to milk caused an increase of hemoglobin to 6.56 grams per 100 cubic centimeters of blood in 6 to 9 weeks, and that when opihi plus 0.01 milligram of copper as the daily supplement was fed, the regeneration was more rapid, the hemoglobin averaging 12.1. The findings confirm those of the Wisconsin investigators who have shown that copper is necessary for hemoglobin building.

Because many of the experimental animals showed abnormally large spleens, a special histological study was made of the spleens of anemic rats and of rats in various stages of recovery, as well as of some additional animals fed milk only and supplements of flour, iron, and iron plus copper. This study was made by C. J. Hamre, of the zoology department of the University of Hawaii. No definite explanation of the cause of enlargement of the spleen was found but it appears to be associated with general resumption of growth induced by the supplementary diets. Results of the studies of the histology of the blood suggested that changes in the spleens during recovery may be connected with the great increase of blood cells.

PROTEIN OF THE PIGEONPEA

Experiments were continued to determine if cystine is a limiting factor of the protein of the pigeonpea (*Cajanus indicus*) for growth, when the seed meal furnished 8 to 11 percent of protein in the diet. Analysis showed that the pigeonpea-seed meal contains more sulphur and therefore probably more cystine or methionine than do other legumes, with the possible exception of soybeans.

NUTRITIVE VALUE OF THE MOUNTAIN APPLE

Analyses, including calcium, phosphorus, and iron, of the mountain apple (*Eugenia malaccensis*) were completed and showed no remarkable qualities in the fruit. Feeding tests showed it to be a poor source of vitamins A, B, C, and G.

HALEAKALA SUBSTATION

An attempt is being made to coordinate the work at the Haleakala substation more closely with the major agronomic projects at the central station at Honolulu. The substation and the four associated tracts at different elevations (at about 1,000-foot intervals) are proving to be of value for a study of the effect of variation in elevation and of climatic influence on crop growth and development.

Selective breeding of pigeonpeas was continued in an effort to develop a strain that will produce good foliage and mature seed satisfactorily at the higher elevations.

The most promising species and varieties of green-manure crops planted in 1930 were selected for further trial. The blue lupine has proved most promising, with the Black Mauritius velvetbean a close second.

Ten varieties of potatoes were tested at Haleakala and at Olinda. British Queen made the best yield at Haleakala, and White Rose ranked first at Olinda.

Some 33 species and varieties of pasture grasses were planted at each of the different elevations at Haleakala, Olinda, Ukelele, Mountain Paddock, and Puu Nianiau.

Other plantings included forage, root, and cereal crops, vegetables, fruits, nuts, and coffee. Comparative tests of eucalyptus and evergreen conifers for use as ornamentals, windbreaks, and fence posts are under way. Planting material of various superior strains of field and root crops, fruits, and vegetables was distributed to private cooperators desiring to try them.

KONA SUBSTATION

Coffee investigations constitute the most important line of work at the Kona substation, island of Hawaii. These include species and variety tests; fertilizer, pruning, and cultural experiments; and studies to determine the best sources of stocks and scions for budding and grafting operations. The Macadamia-nut experiments, also important, include fertilizer, pruning, and cultural tests, and studies to learn the best season and the best method for budding and grafting seedlings to standardize the variety for successful marketing. Variety and cultural tests are also under way with citrus, avocado, breadfruit, pili-nut tree, cashew, figs, Japanese persimmons, litchi, olive, cherimoya, passion fruit, sweetpotato, tomato, and various cover crops.

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